# Notes on a Skeleton of the Musk-Duck, *Biziura lobata*, with Special Reference to Skeletal Characters evolved in relation to the Diving Habits of this Bird.

By W. P. Pycraft, A.L.S., F.Z.S.

[Read 15th June, 1905.]

(Plate 39.)

The following notes on the skeleton of a Musk-Duck (*Biziura lobata*), kindly submitted to me for examination by Prof. C. Stewart, F.R.S., of the Royal College of Surgeons, will, it is hoped, prove of some service, since no similar description has hitherto been published, although several short incidental references are to be found scattered here and there among the papers of Beddard and others.

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The Musk-Duck (*Biziura lobata*) is a native of Australia and Tasmania, and appears to frequent indifferently large lakes, as well as the open sea. An expert diver, it seldom, if ever, it is said, flies in the daytime, though it will do so at night. The Musk-Duck is generally regarded as the close ally of the genera *Thalassiornis*, *Nomonyx*, and *Erismatura*—making 10 species in all—mainly on account of the fact that all are remarkable for the peculiar structure of the tail-feathers, which are long and stiff, hence they are known as "stiff-tailed" ducks. The nearest allies of this small group appear to be the Scaups and Pochards.

Of the Stiff-tailed Ducks—the Erismaturinæ of Count Salvadori—*Biziura* is to be regarded as the most highly specialized member, adaptation tending to increase the diving powers of this bird, having effected several noteworthy changes in the skeleton.

## The Skull.

This, in the specimen submitted to me, was not fully anchylosed, all the cranial sutures are obliterated, but the elements of the upper jaw remain distinct; and these display one or two features demanding notice.

The nasal is a somewhat remarkable T-shaped bone. The frontal process is very long, and extends backwards as far as the middle of the orbit as a spatulate plate; the premaxillary process is rod-shaped, and extends forwards as far as, and beneath, the

nasal process of the premaxilla. The descending process forms a linguiform plate apposed to the outer surface of the maxilla. This bone differs from the typical nasal in that the descending process is placed at right angles, instead of obliquely, to the premaxillary process (Pl. 39. fig. 1).

The *premaxilla* is unusually short and very broad; its extreme tip has been broken off. The inferior surface of this bone is unusually dense, and is not pierced by foramina as is usually the case among the Anatidæ. The aperture of the anterior nares is of great size.

The *maxilla*, partly on account of the relatively small size of the premaxilla, is very largely exposed. The palatine processes are oblong in shape, of considerable size, and, in this specimen, touch one another in the middle line by their postero-internal angles, leaving a large palatine vacuity. The maxillary antrum is shallow.

The quadrato-jugal bar recalls that of the Mergansers and of *Somateria*, in that it turns abruptly upwards to articulate with the quadrate. This is due to the fact that the glenoid cavity or the quadrato-jugal has shifted so as to be nearer the squamosal head of the quadrate.

The *lachrymal* is free and triangular in form, having the descending process long, slender, and curved backwards. The orbital and nasal processes are not well-defined, blending insensibly with the descending process: the orbital process bears a small tubercle near its free end.

The *frontals* are extremely narrow in the orbital region and bear shallow grooves facing outwards from the supra-orbital gland. Anteriorly they are widely separated so as to expose the mesethmoid when the nasal processes of the premaxilla are raised.

The *parietal* region of the skull—the fronto-parietal suture can no longer be distinguished—is long and bounded posteriorly by a narrow and well-defined "temporal fossa," which is continued downwards along the paroccipital process.

The *supra-occipital* is pierced by a small fontanelle, such as is usually met with in the Anatidæ.

The *postorbital* process differs conspicuously from that of the typical Duck, and resembles that of the Mergansers in that it is short and directed downwards. In the normal Ducks this process is of considerable length and directed downwards and forwards.

The interorbital septum is largely fenestrated. The mesethmoid does not extend as far forwards as the free end of the premaxillary limb of the lachrymal. There is no ossified antorbital plate, and no nasal septum. The anterior nares are of considerable size—larger than in *Somateria*.

The hyoid bones differ but little from those of typical ducks. The basi-hyal is of great size, shows traces of its paired origin, and is pierced at the base by a large cordiform fenestra. The 1st and 2nd basi-branchials are fused.

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The skull of *Biziura* may be distinguished from that of all other Anserine birds by the curiously truncated form of the upper jaw; the free lachrymal, which is further remarkable for the great length of the descending processes and the shortness of its horizontal limbs; the short blunt postorbital process; the peculiar shape of the grooves for lachrymal gland, which do not meet in the middle line, nor extend backward beyond the postorbital processes; the great size of the anterior nares; and the perforate interorbital septum.

In the curiously forward tilted position of the quadrate, and the angulated quadrato-jugal, *Biziura* resembles *Somateria* and the Mergansers, but in *Biziura* this feature is most marked.

Although *Biziura* at the present day appears to derive much of its support from the sea, it would seem that it is essentially a freshwater species. And this may be inferred from the small size of the supra-orbital groove for the lachrymal glands, which, in *Somateria* and *Œdemia* for example, extend far backwards as shallow depressions over the roof of the skull, and in *Tachyeres* almost touch the lambdoidal ridge. In *Tachyeres* and *Somateria* this glandular area is increased by the development of the orbital processes of the lachrymal, which project outwards, upwards, and backwards after the fashion of a pair of horns. Deep supra-orbital depressions, more sharply defined, occur in the Sphenisci and the Colymbi, the Petrels and Gulls, and, less well defined, in the Plovers, which swim and dive only on relatively rare occasions. Thus there seem to be good grounds for associating the development of this groove with the necessity for a large supra-orbital gland in marine diving birds. This seems to be supported by the fact that in the Mergansers, which are freshwater diving ducks, this groove is wanting and the gland only feebly developed.

Thus we have a parallel case to the Grebes and Divers. The former are freshwater divers, and have much smaller supra-orbital glands than in the latter, which are marine. Both Grebes and Mergansers, however, are to be met with at sea, the latter commonly, but it would seem that this habitat is of recent date.

In *Tachyeres* and *Somateria* the fore part of the head lying between the orbit and the base of the beak has become enormously elongated, drawing out the nasal limb of the lachrymal to an extent elsewhere unknown among the Anseres. In *Biziura* this region is abnormally short, wherein it agrees with what obtains among the Mergansers. The lachrymal of *Biziura* again also closely resembles that of the Mergansers.

On the whole the skull of *Biziura* resembles that of *Erismatura* more closely than that of any other duck; but differs from this genus in that *Erismatura* possesses an ossified antorbital plate, and a large triangular lachrymal, an unfenestrated interorbital septum, a long postorbital process, and a long spatulate beak. Unfortunately I have no skeleton of any other member of this group of ducks wherewith to carry these comparisons further.

## The Vertebral Column.

Only the thoracic, synsacral, and caudal vertebræ seem to require notice here.

In *Biziura* all the thoracic vertebræ bear long hypapophyses. From the 2nd to the 5th the free ends of the spines expand to form horizontal ⊥-shaped plates.

These hypapophyses have undoubtedly been developed to increase the power of diving; but whether they have been acquired as the direct result of a long-sustained stimulus through a long series of generations—that is to say, by the inheritance of acquired characters—or whether by the selection of favourable variations in this direction, I cannot pretend to say.

It is significant to note that these processes are wanting in the Geese. In non-diving ducks, e.g. *Anas*, only three are present, and these lack the ⊥-shaped process. The Sheldrakes agree with the diving Scaups, having four of these vertebræ with hypapophyses. In the Scoters and Eider-Ducks, which are sea-ducks and expert divers, there are 7 of these processes as in *Biziura*. They are longer and have larger ⊥-shaped plates than in *Anas*, *Fuligula*, or *Tadorna*. *Erismatura*, as we might expect,

most nearly resembles *Biziura* in this matter. It is a curious fact, that in the Mergansers, where one would expect to find these processes extremely well-developed, they are, on the contrary, smaller and fewer than in any other diving ducks—numbering but 5, and having very small ⊥-shaped processes. Taken in conjunction with the fact that these birds differ also from the sea-ducks in the absence of supra-orbital depressions for the supra-orbital gland, it would almost seem as though their partially marine habitat had been adopted quite recently.

Outside the Anseres, hypapophyses occur in the Penguins, Grebes, Divers, Cormorants, and Alcidæ, all types which dive for their food.

In the Penguins the hypapophyses 1–3 have their free ends expanded to form the horizontal plates described in *Biziura*; behind these follow 4 simple processes. In the Divers these expanded free ends occur on 1–2—where they are very large—and 3, where they are small; behind these follow 4 simple spines. In the Grebes—freshwater divers—spines 1–3 have feeble lateral plates and the rest simple. The Alcidæ (Guillemots, Auks, &c.) have extremely well-developed hypapophyses. Here 1–4 have very large lateral plates, 5–8 are simple. In the Cormorants it is somewhat surprising to find all the hypapophyses 1–7 of the simple type—there are no lateral plates. In the Gannet, Pelican, Frigate-birds, &c. these spines are altogether wanting, and this because though they swim much, yet they do not dive. Thus we have a parallel to the case of the Geese and Swans among the Anseres.

The vertebral centra in these diving birds are much compressed laterally.

### The Shoulder-Girdle and Sternum.

There are no points calling for special comment in the shoulder-girdle of *Biziura*. The sternum does not exactly agree with that of any other duck with which I have compared it. The spina externa and interna are wanting. The posterior lateral processes are free, short, and curved, and project beyond the level of the metasternal border. In that these processes are free they resemble those of *Erismatura*, *Somateria*, and *Œdemia*, *Dendrocygna*, and the Geese and Swans. That is to say, in this character these birds represent a less specialized condition than that which obtains in the Ducks generally, where the free

ends of the lateral processes meet the angles of the truncated metasternum to form fenestræ *. In the Sheldrakes and the Red-fronted Goose, for example, the union of these elements is nearly complete.

In *Clangula* the metasternum is of great width, converting the sternal notches into fenestræ by joining with the posterior lateral processes; further, the metasternum is peculiar in that its cartilaginous free edge has become partly ossified. In *Harelda* this cartilaginous element is greatly increased, forming a large linguiform plate, and, at the same time, by increasing the width of the metasternum, it has, in very old examples, converted the sternal notches into fenestræ as in *Clangula*.

In *Biziura* the sternum is relatively longer than in other Ducks, and it also tends to taper anteriorly. The anterior lateral processes are obliquely truncated as in *Erismatura*. In *Erismatura* there is a broad, bifid *spina externa*, but in *Nomonyx* this process is remarkably well-developed, therein agreeing with the Geese. In *Tachyeres* it is moderately large. In all other ducks this process is either vestigial or wanting.

The keel of the sternum in *Biziura* shows evident signs of degeneration, being extremely low, and terminating some distance before reaching the end of the sternal plate. The accompanying illustration will show the relative proportions of the keel between *Biziura* and *Erismatura*. In the marked length of the sternal plate we have an evident adaptation to diving habits.

It is curious to note that the degeneration of the keel in *Biziura* is more marked than in *Tachyeres*, which is actually flightless.

The Mergansers only among the Ducks have the ventral border of the keel produced far forwards, in a fashion recalling that of the Cormorants and Gannets. In *Mergus serrator* this feature is especially well-marked. The precise significance of this is not obvious.

### The Ribs.

The hindmost ribs of *Biziura* recall those of the Colymbi and Alcidæ, in that they are much elongated, running almost parallel with the pubis. Only the first five of the thoracic ribs appear

* *Erismatura vittata* appears to form one of those puzzling exceptions which seem to be inseparable from every rule, inasmuch as the notches are in this bird not only converted into fenestræ, but the closing process has gone so far as to come near the obliteration of the fenestra of the left side altogether.

to bear uncinate processes. In *Fuligula*, as in *Anser*, there are six uncinate-bearing ribs, the first being that commonly regarded as the last cervical, since it does not become attached to the sternum. In *Erismatura* there are seven uncinates, the first attached as in *Biziura*.

There are altogether 10 thoracic ribs in *Biziura*, of which 8 are attached to the sternum, the 9th just fails to reach the sternal border, while the 10th is vestigial. *Erismatura* possesses 9 thoracic ribs, of which 8 are attached. Only in *Anser* and the Swans, it appears, is so high a number of ribs as 10 attained. In *Cygnus buccinator* there are 9 ribs attached to the sternum, while the 10th is of great length.

No less than four ribs are overlapped by the pre-ilia in *Biziura*, and the same is true of *Anser* and *Branta* among the Geese; but in no other Ducks are there more than three overlapped ribs, so far as I have been able to discover.

The great number of ribs in *Biziura* is to be taken as a primitive character, since in the more highly specialized ducks, as in *Querquedula* for example, there are only 8 pairs, of which but 6 pairs reach the sternum.

### The Pelvic Girdle.

The pelvic girdle of *Biziura* is remarkable for its extreme narrowness, which gives it an unusually elongated appearance. This narrowness is partly the result of a reduction of the width of the postacetabular ilium, and partly of the transverse processes of the synsacrum. The result of adaptation to diving habits, this girdle has come to bear a really striking resemblance to that of *Podiceps* or *Colymbus*, in which this narrowness has reached its maximum. As in these birds, so in *Biziura*, the preacetabular ilium has become shortened, while the postacetabular region has become lengthened.

Relatively longer than in any other Anatidæ, the proportions of the innominate bones are markedly different. Thus in *Biziura* the length of the preacetabular ilium from its anterior margin to the base of the antitrochanter is exactly $\frac{1}{3}$ of the whole pelvis. *Mergus* approaches nearest to these measurements, the length of the preacetabular ilium, taken as in *Biziura*, is $\frac{3}{8}$. *Œdemia*, *Somateria*, and *Erismatura* give a measurement of $\frac{3}{7}$.

This forward shifting of the acetabulum is to be taken as a sign of specialization—of adaptation to the requirements of

diving, since a precisely similar modification obtains in the Grebes and Divers.

The pelvis of *Mergus*, among the Ducks, approaches nearest, in its general conformation, to that of *Biziura*. In so far as the reduction in the width of the postacetabular ilium is concerned, indeed, the two genera are practically identical. In both, this portion of the innominate is represented only by a narrow blade of bone twisted so as to lie almost vertically. The peculiarly narrow pelvis of *Biziura* is brought about by the reduction of the transverse processes of the synsacral vertebræ. Between the pre-ilia, indeed, even the neural spines have become reduced (in thickness), so that innominates of this region meet in the middle line to form an almost knife-like edge. In the region between the antitrochanters the pelvis is normally at its broadest. In *Mergus* the innominates are separated one from another for half an inch by the transverse processes of the sacral and neighbouring vertebræ, but in *Biziura* they are divided only by a slightly swollen neural crest. As this is traced backwards the shelf formed by the transverse processes gradually appears, but at its widest the ilia are not separated by more than ·4 of an inch.

Since this extremely narrow type of pelvis occurs both in marine and freshwater species, it would seem either that Eider-Ducks and Scoters, now almost exclusively marine, have only recently become confined to this habitat; or that for some unsuspected reason they have escaped the transforming effects of the environment, so obvious in such homoplasts as the Colymbi and Alcidæ, for example.

The ilio-ischiadic foramen is relatively larger in *Biziura* than in any other of the diving ducks. In the Fuligulinæ it is divided into two by a broad median bar.

The pubes of *Biziura* have very long free ends curving abruptly inwards towards the middle line, so as to very nearly touch one another. In *Mergus*, *Œdemia*, and *Somateria* the free ends of the pubes are yet longer, but are directed downwards and slightly backwards, curving inwards at the same time. The pectineal process is well-developed.

### The Pectoral Limb.

In *Biziura* the humerus is slightly longer than the fore-arm, and in this it agrees with *Erismatura*, *Somateria*, *Œdemia*, *Mergus*, and *Fuligula*, for example. The manus and fore-arm

are subequal, and in this respect *Biziura* and *Erismatura* agree, and differ from all the species herein used for comparison, inasmuch as in these the manus is by far the largest segment of the wing.

Although *Biziura* is a larger and heavier bird than *Somateria*, the wing is altogether of a more slender character; and this is most evident in the manus. The metacarpals are fragile, Mc. II. having a diameter of a little less than $\frac{2}{12}$ in., while in *Somateria* the diameter in the same region is about $\frac{4}{12}$ in. Mc. III. is represented by a long and delicate bar, separated from Mc. II. only by a narrow chink; in *Somateria* Mc. II. is outwardly bowed and much stronger. The phalanges in *Biziura* are much reduced.

Although the wings of *Biziura* and *Erismatura* show the same general proportions in the matter of length, it by no means implies that *Erismatura* stands in such imminent danger of flightlessness as would seem to be threatening *Biziura*, inasmuch as it is a smaller and more active species.

It is interesting to remark that in so far as size is concerned there is little, at first, to indicate the degenerate condition of the wing in the flightless *Tachyeres*. Slightly longer in the humerus than *Somateria*, in the lengths of the fore-arm and manus *Tachyeres* and *Somateria* agree exactly. But the bones in *Tachyeres* are all much thicker than in *Somateria*. The decadent condition of this wing becomes apparent when we reflect that *Somateria* is at least one-third smaller than *Tachyeres*.

This bird, it is generally believed, loses its power of flight after the first moult. But it would seem that not even the young birds fly, since Mr. M. J. Nicoll, writing to the 'Ibis,' 1904, p. 49, remarks: "In most accounts of this bird it is stated that it rows itself along through the water with its little wings at an incredible rate. It certainly goes very fast, but practically it runs in the water flapping its wings clear of it;" and continues: "The young travel through the water nearly as fast as the adults, in which the muscles of the legs are enormously developed." From this it would seem that the decay of the wing began by a reduction in the size of the remiges; later the skeleton became affected. It is, however, a moot point as to whether the skeleton of the wing has, as yet, undergone any appreciable change, inasmuch as in the proportions of its several segments it preserves all the relations of a functional wing.

In so far as the length of the wing is concerned, it is hard to say whether it has really undergone reduction, or whether the disproportion between the size of the wing and of the body is not due to an increase in the latter, while the former has remained stationary. While, however, *Somateria* and *Tachyeres* agree so closely in the matter of the length of this limb, they differ conspicuously in that the several bones thereof in *Tachyeres* are much thicker and heavier, and this seems to show that a shortening process has begun. The evidence so far to hand seems to support one view almost as well as the other. Later I propose to enter with some detail into this question, when dealing with the wings of Struthious birds.

## The Pelvic Limb.

The hind limb of *Biziura* presents some interesting evidences of adaptation in the direction of increased swimming powers. It is a noticeable fact, however, that the relative length of the several segments of the leg have remained practically unaltered; indeed there is a singular uniformity in this matter throughout the ducks generally: *Anas*, for example, on the one hand, the diving ducks on the other, presenting almost the same relative proportions—the femur being about $\frac{3}{5}$ the length of the tibio-tarsus.

Unless the present specimen be abnormal, the femur in *Biziura* is remarkable for its deep dorso-vertical curvature, and the exceptional development of the scars for the origin and insertion of the muscles. In the curvature of the shaft, *Biziura* is nearly approached by *Erismatura*.

The ecto- and entocnemial crests of the tibio-tarsus are well developed. In the form of the entocnemial crest *Biziura* is peculiar in that it is long and low. *Œdemia* approximates very closely to this type, but the crest is deeper. *Erismatura* is intermediate in this particular. In *Tachyeres* the crest is linguiform and of great size.

The tarso-metatarsus is flattened antero-posteriorly, grooved in front, and twisted on itself. The hypotarsus is complex. In its general form the tarso-metatarsus approaches very closely to that of *Tachyeres*, since in both these birds the shaft is unusually stout. In *Somateria*, for example, the shaft is relatively slender, tapering rapidly from the glenoid mesotarsal articular surface.

In the Mergansers it is also slender, and almost quadrangular in section.

The outer and middle toes are of equal length, as in *Tachyeres* and *Somateria*, for example.

In the form of its patella *Biziura* is unique among the Anseres. This sesamoid is of great size, pyramidal in shape, triangular at its base, and rising into a great crest whose anterior border looks inwards: further, as in the Cormorants, it is traversed by a tunnel for the ambiens. In no other duck is the patella completely ossified; and only in *Tachyeres* is there any approach thereto in size, but in this genus it remains fibrous throughout life.

## Summary.

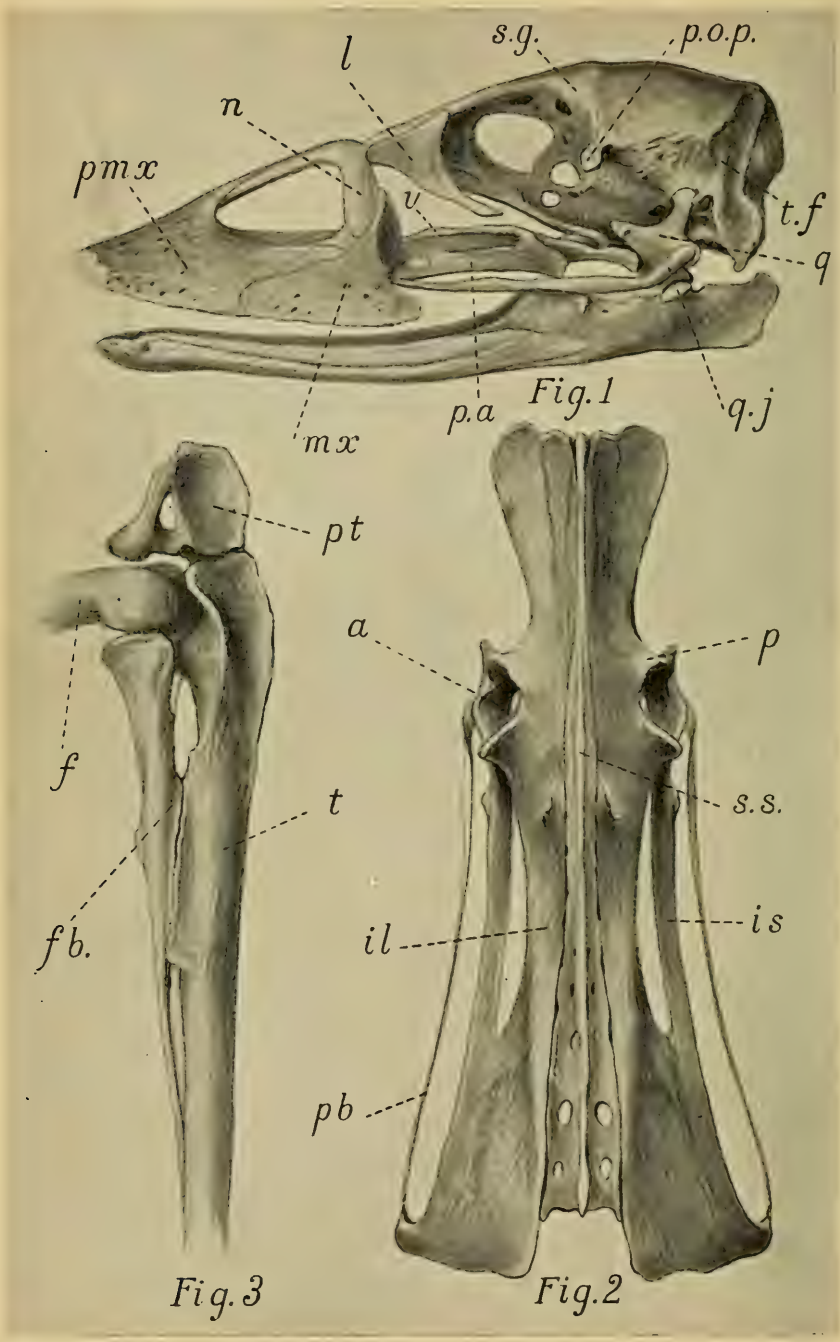
Unfortunately the Erismaturinæ are represented in the National Collection, in so far as skeletons are concerned, only by a single specimen each of *Erismatura jamaicensis* and *E. vittata* and a sternum of *Nomonyx*. This fact, and the still immature condition of the skull in the skeleton of *Biziura* now under consideration, makes any generalization as to the affinities of *Biziura*, as indicated by osteological characters, a matter of difficulty. The genera *Erismatura*, *Thalassiornis*, *Nomonyx*, and *Biziura* have been placed together by Count Salvadori (Cat. Birds Brit. Mus. vol. xxvii.) in a separate subfamily—the Erismaturinæ. This he places between the Fuligulinæ on the one hand, and the Merganettinæ and Merginæ on the other.

The osteological characters of these groups certainly do not seem to bear out this classification.

The Erismaturinæ should be merged in the Fuligulinæ, since they are undoubtedly closely allied to the genera *Aythya* and *Fuligula*, and more distantly to *Clangula*. On the other hand, the genera *Tachyeres*, *Harelda*, *Histrionicus*, *Œdemia*, *Heniconetta*, *Somateria*, and *Erionetta* might well be placed together in a separate subfamily—the Somateriinæ. They have much in common, and are quite distinct from the Fuligulinæ. It is open to question whether the Merganettinæ should be separated from the Merginæ.

*Biziura* is primitive in some respects, in the skull for example, and highly specialized in others, as in the form of the pelvis and of the hypapophyses of the vertebræ.

The remarkable gular pouch of this bird was figured and described by Forbes (P. Z. S. 1882).




H. Grönvold, del

SKULL, PELVIS, AND KNEE-JOINT OF THE MUSK-DUCK.

EXPLANATION OF PLATE 39.

Fig. 1. Skull of *Biziura lobata*, side view.
*l.*=lachrymal. *mx.*=maxilla. *n.*=nasal. *pa.*=palatine. *p.o.p.*=postorbital process. *t.f.*=temporal fossa. *q.*=quadrate. *v.*=vomer.
Fig. 2. Pelvis of *Biziura lobata*, dorsal aspect.
*a.*=acetabulum. *il.*=ilium. *is.*=ischium. *p.*=pre-acetabular ilium. *pb.*=pubis. *s.s.*=synsacral crest.
Fig. 3. Portion of right leg of *Biziura lobata*, outer aspect.
*f.*=femur. *fb.*=fibula. *pt.*=patella. *t.*=tibia.

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# On the Membranous Labyrinths of certain Sharks.

By Charles Stewart, F.R.S., F.L.S.

[Read 16th November, 1905.]

(Plate 40.)

The admirable monograph on the organs of hearing of the Vertebrata by Prof. Retzius * leaves little or nothing that one would wish to add to the account of the forms therein treated; but having had the opportunity of examining some not dealt with in that work, it seems desirable to give some record of their structure.

One cannot but recognize that features apparently most trivial may prove useful in helping to show the real affinities of an organism, and occasionally the solution of the more difficult question of the function of a structure may be suggested, when such a structure is found to be possessed by forms dwelling in a like environment that by other features have had their affinities differently interpreted.

## Notidanus griseus. Fam. Notidanidæ.

In this Shark the utricle presents the ordinary elasmobranch features as figured by Retzius and others, being divided into two portions not directly communicating with one another and with their walls completely separate. In spite of the fact that Retzius reserves the name utricle for the anterior of these, and calls the other posterior canal, I propose speaking of them here as utriculus anterior and utriculus posterior; for a comparison with the utricle of *e. g.* Teleostea leaves no doubt that they are portions of that chamber (*l. c.* p. 218).

The anterior utricle has no direct opening into the saccule, but communicates with it indirectly through the recessus utriculi.

* 'Das Gehörorgan der Wirbelthiere,' Bd. i. (1881).